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POWER PLANTS IN AIRPLANES

V. I. Polikovskiy

(Review of G. I. Volkov's Silovyye ustanovki samoletov (Power Plants in Airplanes), published by Leningrad Army Air Force Engineering Academy, Leningrad, 1947)

This textbook for students at the Leningrad Army Air Force Engineering Academy analyzes power plants of airplanes with reciprocating engines and, to a lesser extent, with jet engines. The work of the national institutes, TsAGI (Central Aero-Hydrodynamic Institute), TsIAM (Central Institute of Aviation Fuels and Oils), etc., and significant foreign materials form the basis of this textbook.

In addition to general formulas and calculating methods, series of values are given for application to concrete problems. More of this very useful information, especially on problems of cooling, intake, and exhaust, would be valuable.

In the book the development of power plants, as a whole, is not studied, and development tendencies are not analyzed. Many as yet unsolved problems in aviation technology (the aerodynamics of high speed, cooling at extreme altitudes, fuel system control, etc.) are treated categorically; and the author's conclusions on these and other problems cannot be evaluated.

Insufficient general information is given on jet engines. Material should be added on the starting of jet engines, on the cooling of engine parts, on the shape of the cowling, on the control and performance of the engine, etc.

Data is lacking on engine mounts and on engine suspension. On the other hand, there is an excess of detail on the design and mechanics of propellers, on the theory of governors (stability, automatic control) and other material which is either obtainable in general theory courses, or better left to specialized courses.

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Chapter 1 is a general treatment of airplane power plants. Comparison between reciprocating and jet engines is not clearly drawn. The weight of the airplane is given without consideration of specific fuel consumption. The assertion that the efficiency of the propeller at a speed of 950-980 kilometers per hour "falls almost to nothing and makes a further increase of the plane's speed by the power plant impossible" is incorrect. An increase in speed above 950-980 kilometers per hour is virtually unattainable by airplanes with reciprocating power plants because of unfavorable gravimetric factors and because of the difficulty of generating sufficient power in a single power plant, and not because of a catastrophic fall in the efficiency of the propeller. At 950-980 kilometers per hour, propellers attain an efficiency range of 0.6-0.7.

Turboprop engines, which have attained speeds of 950 kilometers per hour, are not examined. Since turboprop engines occupy a position between reciprocating engines and turbojet engines, their omission distorts the over-all picture and prevents comparisons between various types of engines. Unwarranted praise is given to Airacobra-type power plants.

The unsubstantiated statement that "installation of the engine in the nose of the fuselage is an advantage" is also made. Any merits of this type power plant are not connected with the aerodynamic advantages in fuselage streamlining.

Referring to jet power plants, the author writes, "Flight with one engine off is facilitated, since the engines can be located closer to the axis of the airplane."

In flight with one engine off, the thrust of the remaining reciprocating engine can be increased by increasing the engine speed, whereas under similar conditions the thrust of turbojet engines remains constant at best. This fact is more important that the relationship between engines and airplane axis. In jet power plants, flight on one engine is made more difficult, and is a definite handicap. The author adds, "Ducts for the passage of air to the engine cause substantial internal drag." He misleads the reader, inasmuch as, in most cases, intake ducts can operate with losses of 100-200 millimeters in water-column pressure and with a lowering of thrust of 2-3 percent and of efficiency of 1.5-2 percent. "Substantial" losses are not caused by the presence of intake ducts, but by faults in their design.

Chapter 2, "Airplane Propellers," deals with the operation of propellers of variable pitch. Comparison is not made between ordinary and reversible type propellers. Too much attention is given to the foreign propellers, "Hydromatic," "Aeroprop," etc., at the expense of native types. According to the author, heavy propellers, sudden maneuvering, or sudden changes in the operation of the engine, lower the thrust of the power plant and the airplane "can lose stability." Actually, lagging by the propeller depends on the work of the engine; stability of the plane is not involved.

Chapter 3, "Fuel Systems," is the first of the important chapters of the book. "The Fuel Systems of Jet Airplanes" is the only unsatisfactory section of this chapter. Data is sketchy; definitive methods have not yet been established; experience must be accumulated.

Chapter 4, "Lubricating Systems," is marred by errors and omissions. In the calculation of high-altitude performance of lubricating systems, the author does not mention the influence of residual air mixed and diffused in the lubricant. The influence of residual air can cause substantial discrepancies between calculation and practice.

The capacity of the lubricating system "to maintain the temperature of the oil under given conditions with a sudden opening of the throttle and some lag in the opening of the oil thermostat" is considered under "pick-up."

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Clearly, this very important quality should be considered as "lag" rather than "pick-up."

Although contemporary opinion agrees with the author that "control of the temperature of the oil should be at the oil inlet," many Soviet motors set and gauge the temperature of the oil at the oil outlet. Omission of such detail makes the work technically inaccurate.

Chapter 5, "Liquid Cooling Systems," examines water cooling of engines. The statement that optimum loss of power in cooling is 10-15 percent is incorrect, since the figure can be much lower. "By increasing the drop in temperature, the surface area of the radiator can be decreased," writes the author. This may be true, but drops in the temperature are utilized for lowering evaporation rather than for decreasing the surface area of radiators.

Chapter 6, the best in the book, treats of cooling devices in power plants. The author examines in detail all the processes and problems involved in cooling devices, carefully utilizing materials from the investigations of the aviation institutes of the USSR. However, in examining air-cooled systems, he does not utilize the most modern methods for determining the necessary cooling under ideal mean temperature of the gas in the cylinder.

He incorrectly states that a lowering in drag is achieved at the expense of heating of the air, and that an escape of air from the radiator "is accompanied by the appearance of reactive forces." Drag rather than reactive force is the real problem.

Chapter 7 examines intake systems of airplanes with reciprocating and jet engines. In the section on "Intake Systems in Jet Airplanes," the statement is made that a decrease in utilization of ram pressure will decrease the thrust and efficiency of the engine at the same rate. Actually, the primary cause for a lowering of thrust and a loss in intake, i.e., a lowering of pressure ahead of the compressor, is a decrease in air consumption and an approximately proportional decrease in fuel consumption. The relative decrease in efficiency is substantially (1.5-2 times) less than the relative decrease in thrust. The influence of boundary layers along the intake duct in oversimplified.

Chapter 8 considers exhaust systems in reciprocating and jet engines. The study and analysis of work on jet exhaust ducts is based on old material. Recent changes, introduced in work on exhaust ducts by supercharging and scavenging, are not taken into account.

The author makes the incorrect assertion that the loss of power to the engine caused by drag in the exhaust is slight. In an evaluation of the advantages of jet exhaust ducts, he writes that "the average rate of discharge of gas from these ducts is higher than the rate of discharge from exhaust manifolds." Actually, the total area of the exhaust sections of individual ducts is much greater than the total area of exhaust manifolds.

Chapter 9 contains useful information on wiring, tubing, and lubricating systems of turbocompressors, etc. Comparison is made between turbocompressors and jet exhaust ducts with regard to the utilization of the energy of exhaust gases. However, problems dealing with selection of turbocompressors, structure and performance of power plants, relationships between the work of turbocompressors and the work of supercharging systems, important in a study of turbocompressor plants, are omitted.

Chapter 10 deals with water injection, which should have been taken up in the sections on cooling. The author frequently speaks of the possibility of using water injection to increase the efficiency of the engine. Additional consumption of fuel and water makes the application of water injection uneconomical.

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Chapter 11 examines external means of starting reciprocating engines. Even elementary theoretical problems dealing with the activities of electric reluctance and the thermodynamics of air systems of starting are omitted.

Chapter 12 includes material dealing with the fireproofing of power plant equipment, usually not included in courses on power plants despite its importance.

Chapter 13 examines direct and automatic control systems for reciprocating engines. The chapter does not include many important problems on mounts, stops, relationships between changes in the position of controls and deviations in the control parameter, recording and control devices, etc. Studies of direct and automatic control systems for gas turbine engines are also omitted.

Despite many shortcomings, the book is much better than any previous textbooks on power plants in airplanes. Since this book deals primarily with reciprocating engines, supplementary material is necessary for courses on power plants in turbojet engines.

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